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EFFECTS OF SEX RATIO AND FEMALE DENSITY ON PROGENY SURVIVAL OF THE ALFALFA LEAFCUTTER BEE (HYMENOPTERA: MEGACHILIDAE)

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Abstract.—This paper reports the results of two 3-year studies on the effects of: 1) sex ratio in the parental generation on percent live larvae and immature mortality in the progeny; and 2) the density of females on percent live larvae and immature mortality in the progeny. In both studies there were no consistent significant differences between treatments in percent live larvae or immature mortality in the progeny.

Key Words.—Insecta, alfalfa leafcutter bee, *Megachile rotundata,* alfalfa seed

The alfalfa leafcutter bee, *Megachile rotundata* (Fabr.), is the primary pollinator of commercial alfalfa seed in the Pacific Northwest of the United States and southwestern Canada (Richards 1984, Mayer et al. 1990). U.S. alfalfa seed growers in the U.S. often purchase leafcutter bees in 3.79 liter units (gallon) (about 10,000 cells) from producers in Canada because, in many cases, these bees do not reproduce well when used for alfalfa pollination in the U.S.

A major problem with the alfalfa leafcutter bees bred in the U.S., other than chalkbrood, is the high death rate of eggs and young bee larvae (immature mortality) which has reached 60% or more (Bohart 1972). Larval mortality has been attributed to a variety of factors including insecticide residues (Waller 1969), nutrition (Bohart 1972) and parasitism, bee senility, unidentified diseases, overcrowding in domiciles resulting in bee confusion, type of nesting media, lack of food resources and excessive competition for these resources (Arnett 1981). Goesk et al. (1988) found the ratio of males to females had an effect on percent females and I thought there may be some other effects on progeny.

This paper reports the results of two 3-year studies on the effect of the sex ratio in the parental generation and female density on percent live larvae and immature mortality.

METHODS AND MATERIALS

New sterilized nest blocks were prepared annually by taping laminate wood pieces (1 cm × 13 cm × 12 cm) together with strapping tape to form small blocks with 104 nesting tunnels, and covering the back of each block with aluminum foil. Tunnels were 5 mm in diameter and 12 cm deep. One nest block was placed in each cage.

Loose bee cells were obtained annually from Mr. Pollination Services in Canada during the winter and stored at 3° C for about 36 weeks. These bees contained no chalkbrood. In the spring, the cells were removed from storage and incubated at 28–29° C. Adults that emerged after about 19–21 days were allowed to fly in the laboratory and males and females were counted and collected into separate vials. The adults were then released into the cages containing blooming alfalfa and the nest blocks.

Table 1. Effect of number of male leafcutting bees on percent live larvae (LL), immature mortality (IM), dead mature larvae (DL) and pollen masses (PM). Prosser, WA.

Females to males	1990				1991				1992			
	LL	IM	DL	PM	LL	IM	DL	PM	LL	IM	DL	PM
1:6	89a	6a	5a	0a	59a	26ab	3a	12a	65a	25a	2a	8a
1:3	77a	15a	7a	1a	66a	23a	1a	10a	60a	28ab	4a	8a
1:2	86a	8a	4a	0a	56ab	31ab	5a	8a	58a	35b	3a	4a
5:1	86a	8a	6a	0a	47b	42b	5a	6a	61a	32ab	1a	6a

Means within a column followed by the same letter are not significantly different at the $P = 0.05$ level, Newman-Keuls studentized range test.

For the sex ratio study, 16 cages (6 × 6 × 1.8 m) and for the female density study, 12 similar cages were erected over different plots of blooming alfalfa at Prosser, WA. For sex ratio studies, 80 females were put in each cage and then males were added to obtain a 6:1 male to female ratio in each of 4 cages, 3:1 ratio in each of 4 cages, 2:1 ratio in each of 4 cages, and 1:5 ratio in each of 4 cages. This method led to differences in male density between treatments. However, males feed only on nectar and nectar is constantly produced by alfalfa flowers until the flower is tripped. For female density studies 52 females were put in each of 4 cages (1 female : 2 tunnels), 104 females were put in each of 4 cages (1 female : 1 tunnel) and 208 females in each of 4 cages (2 females : 1 tunnel). Males were put in the cages at the same time and in equal number to females (1:1). Thus both nesting density effects and provisioning resources were limitations. Bees were put in the cages on 30 Jul 1990; 5 Jul 1991; and 15 Jul 1992.

The bees foraged and constructed cells in the nest blocks during each season. At the end of the nesting season (August) all the bee cells were extracted from the laminate boards and put into cold storage at 3° C. During each winter the cells were cut open, inspected and the number of live prepupae, dead eggs or young larvae (instars 1–3), dead older larvae and pollen masses (no visible egg or larva) recorded. I examined all the cells produced each year.

The data were analyzed as a randomized complete block design after transformation by analysis of variance, with Newman-Keuls studentized range test for mean separations (Lund 1989).

Results and Discussion

The total number of cells produced for the sex ratio studies were 1849 (6:1 ratio), 2008 (3:1 ratio), 2080 (2:1 ratio), and 2061 (1:5 ratio). The total number of cells produced for the female density studies were 1492 (1 female : 2 tunnels), 1282 (1 female : 1 tunnel) and 767 (2 females : 1 tunnel).

There were no consistent significant differences among sex ratio treatments in the percent live larvae, mortality of immature stages, dead mature larvae or pollen masses (Table 1). In 1990, there were no significant differences between treatments in live larvae ($F = 1.37$, $P = 0.314$, SE = 3.64), immature mortality ($F = 1.85$, $P = 0.195$, SE = 1.86) dead mature larvae ($F = 0.47$, $P = 0.709$, SE = 2.54) or pollen masses ($F = 2.08$), $P = 0.173$, SE = 0.364). In 1991, there were no significant differences between treatments in immature mortality ($F = 2.45$, $P = 0.131$, SE = 5.27), dead larvae ($F = 2.35$, $P = 0.141$, SE = 1.84) or pollen

Table 2. Effect of number of female leafcutting bees per tunnel on percent live larvae (LL), immature mortality (IM), dead mature larvae (DL) and pollen masses (PM). Prosser, WA.

Females per tunnel	1990				1991				1992			
	LL	IM	DL	PM	LL	IM	DL	PM	LL	IM	DL	PM
1:2	82a	7a	8a	3a	54a	33a	7a	6a	60a	25a	7a	7a
1:1	82a	9a	6a	3a	50a	37a	4a	9a	54a	32a	5a	9a
2:1	87a	6a	5a	2a	52a	32a	6a	9a	56a	36a	5a	3a

masses (F = 1.61, P = 0.254, SE = 1.91). However, there were significantly fewer live larvae (F = 0.49, P = 0.700, SE = 3.5) in the 1:5 sex ratio as compared to the other treatments. Though not significant there appeared to be more immature mortality in this treatment. In 1992, there were no significant differences between treatments in live larvae (F = 1.98, P = 0.296, SE = 4.32), dead mature larvae (F = 2.04, P = 0.149, SE = 0.48) or pollen masses (F = 2.12, P = 0.135, SE = 1.85). However, there were significant differences between treatments in immature mortality (F = 12.5, P = 0.018, SE = 4.73) although there were no apparent correlations with the other two years of the study. It appears that immature mortality is the major variable factor and dead mature larvae and pollen masses are of lesser importance. Mortality of immature stages appeared to be somewhat higher in 1991 and 1992 as compared to 1990. The sex ratio in a population appears to have little or no effect on mortality of the immature stages of their progeny.

Female density had no significant effect among treatments in 1990 in the percent live larvae (F = 0.81, P = 0.818, SE = 2.74), immature mortality (F = 2.46, P = 0.432, SE = 1.26), dead mature larvae (F = 3.03, P = 0.123, SE = 1.24) or pollen masses (F = 0.47, P = 0.646, SE = 0.76) (Table 2). Female density had no significant effect among treatments in 1991 in the percent live larvae (F = 0.21, P = 0.818, SE = 3.65), immature mortality (F = 0.09, P = 0.911, SE = 3.55), dead mature larvae (F = 1.45, P = 0.307, SE = 1.25), or pollen masses (F = 3.47, P = 0.10, SE = 1.36). Female density had no significant effect among treatments in 1992 in the percent live larvae (F = 0.62, P = 0.561, SE = 2.85), immature mortality (F = 3.05, P = 0.185, SE = 3.21), dead mature larvae (F = 1.26, P = 0.285, SE = 1.020, or pollen masses (F = 2.48, P = 0.408, SE = 3.4).

Mortality of immature stages does not appear to be affected by different sex ratios or the female density and the results were fairly consistent over three years.

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Literature Cited

Arnett, W. H. 1981. Factors influencing egg and early larval leafcutting bee mortality (pollen mass). Proc. Ann. Interstate Alfalfa Seed Growers School, 12: 1–3.

Bohart, G. E. 1972. Management of wild bees for the pollination of crops. Ann. Rev. Entomol., 17: 287–312.

Gosek, J., A. Ruszkowsi, M. Bilinski & K. Kaczmarska. 1988. The percentage of females in the

progeny of the lucerne leafcutter bee (*Megachile rotundata*) in relation to the percentage of females in the parent generation and to the breeding line and population density. Pszczelnicze Zeszty Naukowe, 32: 99–110. (In Polish.)

Lund, R. E. 1989. MSUSTAT statistical analysis package 4.12. Montana State University, Bozeman, Montana.

Mayer, D. F, J. D. Lunden & E. R. Miliczky. 1990. Effects of fungicides on chalkbrood disease of alfalfa leafcutting bee. Appl. Agr. Res., 5: 223–226.

Richards, K. W. 1984. Alfalfa leafcutter bee management in Western Canada. Agr. Canada Publ. 1495/E. 53 pp.

Waller, G. D. 1969. Susceptibility of an alfalfa leafcutting bee to residues of insecticides on foliage. J. Econ. Entomol., 62: 189–92.

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